MONTANA
DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

Emerald Ash Borer Readiness and Response Plan

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Montana Department of Natural Resources and Conservation
Forestry Assistance Bureau

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EXECUTIVE SUMMARY

Emerald ash borer (EAB) is a non-native, invasive beetle that kills healthy ash trees. It was first detected in Michigan in 2002 and has since been identified in Arkansas, Colorado, Connecticut, Kansas, Kentucky, Illinois, Indiana, Iowa, Georgia, Maryland, Massachusetts, Minnesota, Missouri, New Hampshire, New York, North Carolina, Ohio, Ontario, Pennsylvania, Quebec, Tennessee, Virginia, West Virginia, and Wisconsin. EAB has not yet been detected in Montana, but there is a tremendous likelihood that it will be introduced in the foreseeable future.

EAB was likely introduced into Michigan from Asia in infested solid-wood packing material. The insect can also be transported in nursery stock and firewood, both of which are commonly brought into Montana. Montana's recreation appeal draws hunters, anglers, campers, RVer's, and various other tourists into the state. These tourists often bring firewood that can harbor undesirable insects such as EAB.

Montana has a lot to lose if EAB is introduced. Many of our communities and shelterbelts are planted with ash trees. Eastern riparian corridors are lined with ash as well. EAB has the potential to drastically change our communities and rivers by killing the trees that provide shade, erosion control, wildlife habitat, shelter, and aesthetics. A recent survey indicates that in some communities, such as Helena and Dillon, ash represents more than 60% of all city-owned trees. Overall, ash comprises approximately 30% of all trees planted in Montana communities.

The Montana Department of Natural Resources and Conservation (DNRC) has been preparing for an introduction of EAB. The "Emerald Ash Borer Readiness and Response Plan" outlines the DNRC's approach to EAB including:

- Prevention
- Risk assessment
- Early detection
- Mitigation and eradication
- Communication
- Restoration and utilization

The specific tactics will change in time as policies are developed and science advances. Thus, this document will be periodically revisited and updated. Any response will incorporate multi-agency input and involvement. Two primary functions of this plan are to 1) outline the DNRC's preparedness and planning for an introduction of EAB and 2) collect stakeholder contact information prior to an EAB detection and response. EAB will affect a great diversity of stakeholders so efficient communication among us is critical for an effective response.

TABLE OF CONTENTS

PURPOSE AND NEED:

Emerald ash borer (EAB) (*Agrilus planipennis* Fairmaire) (Coleoptera: Buprestidae) is a non-native, invasive insect pest of ash (*Fraxinus* species.) It was first detected in Michigan in 2002 but is thought to have been present there since mid-1990. It was likely introduced from Asia in solid-wood packing material. As of 2014, EAB has not been detected in Montana, but the likelihood and consequences of an introduction warrants advance planning.

Since the initial detection, EAB has killed millions of ash in Midwestern and eastern forests and communities, and has most recently been detected in the Rocky Mountain region of Colorado (October, 2013). Removing and replacing trees infested with EAB, or treating with chemicals, has cost communities, property owners, nurseries, and the forest products industry tens of millions of dollars, and is expected to cost more than 10 billion between 2009 and 2019 (Kovacs et al. 2009).

The beetles kill ash trees by feeding in the phloem tissue between the bark and the sapwood, disrupting critical nutrient transport and essentially girdling the tree. Adults mate on the exterior of the tree and lay eggs on the bark. The eggs develop into larvae that bore into the tree and feed in a serpentine gallery pattern within the phloem. The beetles are difficult to detect and can cause significant damage to a tree before decline symptoms are evident. Symptoms include thinning crowns, epicormic shoots near the base of the tree, and D-shaped exit holes on the main stem. Commonly, EAB infestations occur for years prior to detection.

Although ash is not present in Western Montana's commercial forests, it is one of the most prevalent landscape species in Montana's urban landscapes. Preliminary estimates suggest that ash represents up to 65% of city-owned trees in many of Montana's communities (Appendix D). Communities rely on ash, particularly green ash (*Fraxinus pennsylvanica* Marsh.), to shade homes, line boulevards, provide shelter from the wind, and regulate storm water. Green ash, the only native ash species in Montana, comprises a significant component of riparian corridors in Eastern Montana (Appendix E) and provides critical wildlife habitat and shelter for livestock. Some of these riparian ash forests are already threatened by invasive grasses, diseases, and overgrazing (Lesica and Marlow 2011, Lesica et al. 2003).

Emerald ash borer adults can generally fly two miles in search of a suitable host (Taylor et al. 2006), but the primary mode of dispersal over great distances has been by human transport of nursery stock, wood packing material, and firewood. Montana is a popular hunting and recreation destination; this often translates to movement of firewood from out-of-state. It is estimated that there are approximately 235,000 opportunities a year for import of EAB-infested ash firewood into MT (Foley 2010). Preventing an EAB introduction requires close monitoring of the potential host material that enters Montana. To date, there are no regulations in effect that restrict firewood movement into Montana, although quarantines in infestation zones of other states regulate the export of hardwood material.

CURRENT EFFORTS:

The Montana DNRC is currently focusing its efforts on prevention and early detection of EAB. A variety of projects are underway and cooperators include Animal Plant Health Inspection Service (APHIS), Montana Department of Agriculture (MDA), Montana State University (MSU) Extension, Montana Department of Fish, Wildlife, and Parks (FWP), USDA Forest Service (USFS), and The Nature Conservancy (TNC) in a variety of projects. Recognizing that firewood is a likely pathway for EAB into Montana, the DNRC has partnered with TNC's "Don't Move Firewood" campaign. TNC developed outreach materials outlining the risks of firewood transport and specifically requesting that visitors not bring firewood to Montana. The message has been formatted as a postcard and mailed to non-resident hunting licensees for each hunting season beginning in 2009. Posters have been hung in campgrounds, rest areas, and information kiosks at parks. Ads have been run in travel magazines, on various travel and recreation websites, and on billboards.

In conjunction with APHIS and MDA, the DNRC installs and monitors EAB traps throughout the state. However, trap efficacy is limited and it is likely that initial detection will be made by report of a symptomatic tree. The DNRC is therefore working closely with MSU extension agents and tree care professionals to conduct a statewide education and outreach campaign. For example, funds from the USFS Forest Health Monitoring program supported workshops in 30 communities aimed to educate master gardeners, arborists and tree care professionals, extension agents, nursery personnel, groundskeepers, natural resource managers, and interested public in the detection of EAB and proper sample submission protocol. Similar workshops are conducted on an annual basis through the Montana DNRC Forest Pest Management and Urban and Community Forestry Programs. Pest alerts, EAB detection kits, and vials containing an adult EAB (dead and preserved in alcohol) for purposes of comparative identification have been distributed throughout arborist, tree care, nursery, natural resource, and recreation professional communities.

The Montana Urban and Community Forestry Association has initiated a destructive sampling program modeled after methods proposed in Ryall et. al. (2011). This method encourages tree care professionals to prune two branches per tree from the mid-crown of both symptomatic and asymptomatic ash trees. The samples are then peeled to expose any potential EAB larvae or galleries. This data is collected and stored with the Montana Department of Agriculture. The sampling protocol can be found at: http://dnrc.mt.gov/Forestry/Assistance/Urban/Documents/2013/EABMtProtocol.pdf or obtained by contacting Jamie Kirby (jamiekirby@mt.gov) or Ian Foley (ifoley@mt.gov).

SCOPE AND INTENT:

The intent of the Montana DNRC's EAB Readiness and Response Plan is to outline the Department's role in prevention, detection, eradication, communication, and restoration in relation to EAB. In many cases, the DNRC will work in conjunction with our federal, State, tribal, university, community, and private partners. This plan does not present these entities' potential responses to an EAB infestation, but rather identifies partnerships and collaborative efforts. Furthermore, this is not a static document; the plan will be revised periodically to reflect changes in technology, science, and legislation.

OBJECTIVE 1: PREVENTION

Ideally, the DNRC would like to prevent an introduction of EAB into Montana. Emerald ash borer generally does not fly more than two miles on its own (Taylor et al. 2006), but can travel great distances via human transport. The most likely pathway of introduction of EAB into Montana is in infested wood products, particularly firewood. Campers, hunters, RVers, and vacation residents often bring firewood from their home states when they recreate in Montana. This firewood could potentially harbor a variety of non-native insects and diseases, including EAB. Thus, limiting the transport of firewood into Montana from out-of-state can effectively reduce the likelihood of introducing these pests.

ACTIONS:

1. Discourage the movement of potentially infested material into the state, particularly firewood.
    a. Continue to mail “Don’t Move Firewood” outreach postcards to non-resident hunting licensees.
    b. Post and (or) publish “Don’t Move Firewood” ads on travel and recreation websites and in magazines.
    c. Cooperate with interstate efforts to communicate the “Don’t Move Firewood” message via billboards, public service announcements, etc.

2. Encourage people who have brought firewood from out-of-state to burn it entirely and not leave any behind. Post this information:
    a. On travel and recreation websites and in magazines.
    b. At interstate travel rest stops.
    c. At campground kiosks and registration portals.

OBJECTIVE 2: RISK ASSESSMENT AND POTENTIAL IMPACT

Green ash, *Fraxinus pennsylvanica* Marsh., is the only ash species native to Montana. Knowledge of green ash distribution within its native habitat will facilitate targeted detection and control efforts. Under natural conditions this species is generally confined to breaks in topography where more moist soils are found, such as in draws and along riparian corridors in eastern Montana (Lesica 2011). These forests are isolated, but where they grow along riparian corridors they form linear features which could facilitate EAB spread.

Green ash is a common street tree and comprises a significant portion of the public trees in many communities (Appendix D). Urban trees are highly valuable for aesthetics, shade, windbreaks, and noise and air pollution absorption. Typically, new trees are planted where a tree has died. Therefore, the loss of an urban ash tree equates to a direct loss of value(s) but also represents removal and replacement costs. Urban tree inventories will allow the DNRC to anticipate which communities are more vulnerable to extensive tree loss.

ACTIONS:

1. Determine abundance and distribution of ash in communities throughout the state.
    a. Conduct additional inventories of publicly-owned trees.
    b. Analyze current inventories of publicly owned trees (Appendix D).
2. Gather information on native green ash distribution in Montana.
    a. Obtain Forest Inventory and Analysis (FIA) data from the USFS to estimate the distribution, acreages, and number of green ash in Montana.
    b. Summarize literature on natural ash distribution and condition in Montana.
3. Estimate the risk and cost of an EAB infestion(s).
    a. Use urban inventory data and native distribution data to identify high-risk areas and EAB-susceptible communities.
    b. Utilize Purdue University's "Emerald Ash Borer Cost Calculator" or the "Emerald Ash Borer Planning Simulator" (EAB-PLANS) to estimate the costs of different EAB management options for specific, high-risk cities.

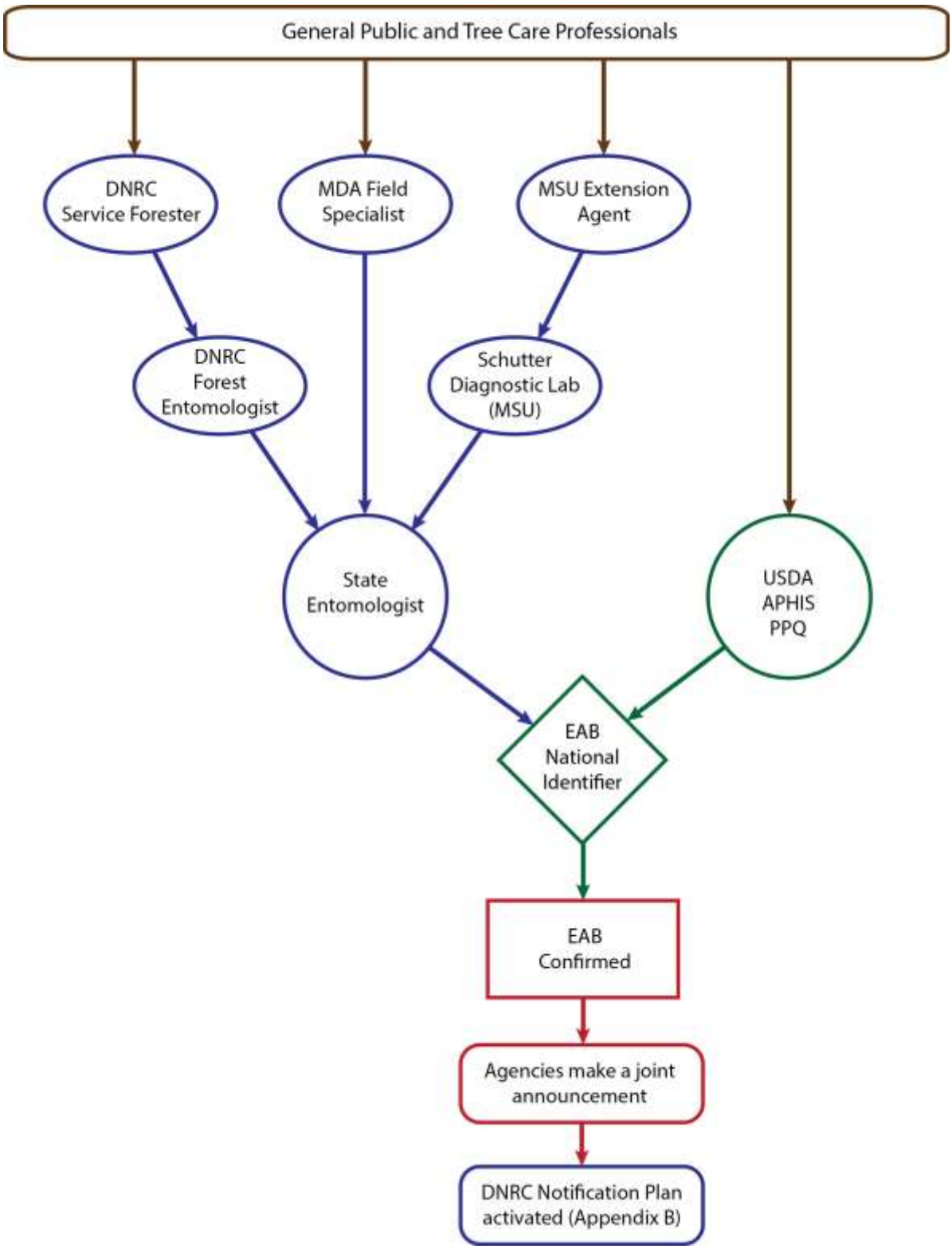
OBJECTIVE 3: EARLY DETECTION

Emerald ash borer is difficult to detect. Current trap technology is not especially effective and trees can be infested with EAB for years before they show signs of decline. Nonetheless, early detection is critical to effectively eradicate the insect, limit the impacts of an infestation, and (or) reduce the probability of transporting infested wood from a recent or localized infestation to un-infested areas or communities. The best method of detection is public awareness. Many outbreaks of non-native, invasive organisms have been detected by citizens who recognize the organism or its damage and contact their local government.

ACTIONS:

1. Deploy traps to assist in early detection of EAB.
    a. Continue to set and monitor strategically placed traps as funding and resources allow.
    b. Adjust trapping methodology, types, and baits as technology and science progresses.
2. Train local arborists and tree care professionals, tree boards, gardeners, and the general public to recognize signs of an EAB infestation.
    a. Educate communities on the importance of EAB early-detection through public meetings and presentations.
    b. Distribute EAB identification kits, samples, brochures, and training videos to citizens and professionals most likely to encounter an EAB infestation.
    c. Assist in destructive branch sampling for EAB detection and verification.
    d. Train extension agents on insect taxonomy and EAB identification at specialized workshops.
3. Follow established protocol for identification of suspect sample. (Flow chart on next page)

EMERALD ASH BORER SAMPLE SUBMISSION PROTOCOL



CONTACT INFORMATION FOR EMERALD ASH BORER SAMPLE SUBMISSION PROTOCOL

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OBJECTIVE 4: MITIGATION AND ERADICATION

Communities can prepare for the detrimental impacts of an invasive tree pest, such as EAB, by understanding the risk of an introduction, assessing resources necessary and available to deal with the consequent damage, and preemptively diversifying species. The DNRC has done extensive street tree inventories to determine the distribution of ash and identify communities that would be most affected by an EAB introduction. The DNRC has also encouraged communities to diversify tree species and will continue its education and outreach efforts.

In the event of an introduction, the DNRC will follow MDA and APHIS's recommendations. If possible, the DNRC aims to eradicate isolated introductions, but eradicating a wide-spread infestation may be an impossible task.

ACTION:

1. Promote a diversity of tree species in our communities prior to an EAB introduction (DNRC Urban and Community Forestry Program).
    a. Provide education and outreach on species diversity to tree boards and community staff.
    b. Perform community inventories to assess tree species composition and condition.
    c. Encourage urban foresters and tree boards to use existing data to dictate future plantings.
    d. Provide assistance to communities that endeavor to create EAB response plans.
2. Conduct delimitation survey to determine extent/severity of EAB infestation.
    a. DNRC will solicit funding for an EAB delimitation survey.
    b. DNRC will hire and train survey personnel as budgets allow.
    c. If another agency assumes this responsibility, DNRC will assist as requested.
3. Cooperate with APHIS and MDA mitigation/eradication measures based on currently recommended treatments (Appendix C) that may include:
    a. Cutting and chipping infested trees, establishing marshalling yards.
    b. Fumigating or kiln drying infested material.
    c. Chemical injections to save living trees.
    d. Release of biocontrol organisms only with appropriate permits (APHIS PPQ 529 permits).
4. Comply with any regulations imposed by APHIS and (or) MDA that may include:
    a. Quarantines.
    b. Firewood and other wood-product transport restrictions.
    c. Nursery stock movement restrictions.

OJECTIVE 5: COMMUNICATION

In the event of an EAB introduction, swift and efficient communication will be essential to garner the resources and assistance necessary to control the infestation. The primary agencies involved in the detection and announcement of an EAB infestation will compose a unified message to release to the media and interested parties. A comprehensive list of contacts is included in this plan. (If changes or additions are identified, please contact Amy Gannon at agannon@mt.gov.)

ACTIONS:

1. Post Montana DNRC's "EAB Readiness and Response Plan" on DNRC website.
2. Communicate incident-specific messages using an Incident Command System employing the communication tools listed in the notification plan (Appendix A) and reaching the contacts listed.
3. Update the notification plan on regular basis to maintain relevancy and availability in the case of an EAB introduction.

OBJECTIVE 6: RESTORATION AND UTILIZATION

Since the initial detection in 2002, EAB has killed millions of ash trees in Michigan alone. Additionally, many more trees have been proactively removed to avoid infestation. The cost of removing these trees has overwhelmed municipal budgets and, in many neighborhoods, replacement is not feasible. The Montana DNRC Urban and Community Forestry Program will aim to reestablish trees in affected communities within budget constraints.

ACTIONS:

1. Plant trees in communities, shelter belts, and along riparian corridors where ash have been killed by EAB.
    a. Create an urban tree and shelterbelt planting plan that emphasizes species diversity.
    b. Utilize existing cost-share programs and solicit additional funding for restoration projects.
    c. Coordinate with the Montana DNRC Conservation Seedling Nursery for restorative plantings in shelterbelts and riparian corridors.
    d. Solicit grants and other funds to cover expense of replacement plantings.
2. If the nature of the infestation creates a large volume of wood in a situation or locale where it could be utilized, work with the DNRC Forest Products and Biomass Program to develop opportunities for ash wood utilization within regulatory guidelines.

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APPENDIX A. EMERALD ASH BORER NOTIFICATION PLAN

1. PURPOSE:

If EAB is detected in Montana, several state and federal agencies will likely partner to contain or slow the spread. A clear, concise communication plan will be essential to communicate with partners and stakeholders. This plan will be used during both immediate (initial EAB discovery) and long-term events. The communication plan will be used to 1) share information in a timely, consistent and appropriate manner; 2) increase awareness and understanding of the situation; and 3) gain the support for and compliance with incident management objectives and strategies.

2. COMMUNICATION GOALS & OBJECTIVES:

Goals:

- Communicate a coordinated and common message within the Incident Command System.
- Communicate current status/distribution of EAB in Montana to target audience.
- Relay plan of action to target audience.
- Garner support and compliance for any regulatory action that is implemented.

Communication Tools:

- Town Hall meetings in EAB infested area.
- Interviews, press releases, and public service announcements with mass media including television, radio, and newspaper.
- Direct contact with representatives from target audience.
- Social media outlets.
- Internet outlets:
  - http://dnrc.mt.gov/forestry/assistance/pests/
  - http://www.emeraldashborer.info
  - http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/index.shtml
- Email listserves of stakeholder groups.
- Direct mail and doorhangers.
- Billboards.
- Information posted at tourism areas and community trap lines.
- Brochures and fact sheets.

3. TARGET AUDIENCES FOR EMERALD ASH BORER COMMUNICATION PLAN

MEDIA

Associated Press in Montana
321 Fuller Avenue
Second Floor
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Phone: 406-442-7440 or 800-221-0094
Email: apmonana@ap.org

Montana Newspaper Association
Expedition Block
825 Great Northern Blvd.
Suite 202
Helena, Montana 59601
Phone: 406-443-2850

STATE PARTNERS

MSU Extension Agents
Agents listed by county at: http://www.msuextension.org/localoffices.cfm

DNRC Service Foresters
Foresters listed by location at: http://dnrc.mt.gov/forestry/Personnel/div/SvcForesters.asp

Montana Department of Agriculture Field Specialists
Listed by office location at:
http://agr.mt.gov/agr/About/Staff/FieldOffices/CommodityServicesAndPestManagement.html

Montana Fish Wildlife and Parks (FWP)
1420 East Sixth Avenue
P.O. Box 200701
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MONTANA STATE PARKS

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Main: 406-538-1900

Missouri Breaks Interpretive Center
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or 877-256-3252 (toll free)

USDA Forest Service Region 1
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APPENDIX B. NATIONAL EMERALD ASH BORER PEST ALERT

Pest Alert

United States
Department of Agriculture
Forest Service
Northeastern Area
State and Private Forestry
NA-PR-02-04
Revised September 2008

Emerald Ash Borer

A beetle from Asia, *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), was identified in July 2002 as the cause of widespread ash (*Fraxinus* spp.) tree decline and mortality in southeastern Michigan and Windsor, Ontario, Canada. Larval feeding in the tissue between the bark and sapwood disrupts transport of nutrients and water in a tree, eventually causing branches and the entire tree to die. Tens of millions of ash trees in forest, rural, and urban areas have already been killed or are heavily infested by this pest.

A. planipennis has been found throughout Michigan, across much of Ohio, and in parts of Indiana, Illinois, Maryland, Missouri, Pennsylvania, Virginia, West Virginia and Wisconsin. Infestations have also been found in more areas of Ontario and in the province of Quebec. The insect is likely to be found in additional areas as detection surveys continue. Evidence suggests that *A. planipennis* is generally established in an area for several years before it is detected.

The broad distribution of this pest in the United States and Canada is primarily due to people inadvertently transporting infested ash nursery stock, unprocessed logs, firewood, and other ash commodities. Federal and state quarantines in infested states now regulate transport of these products.

Identification

Adult beetles are generally larger and brighter green (Fig. 1) than the native North American *Agrilus* species. Adults are slender, elongate, and 7.5 to 13.5 mm long. Males are smaller than females and have fine hairs, which the females lack, on the ventral side of the thorax. Adults are usually bronze, golden, or reddish green overall, with darker, metallic emerald green wing covers. The dorsal side of the abdomen is metallic purplish red and can be seen when the wings are spread (Fig. 2). The prothorax, the segment behind the head and to which the first pair of legs is attached, is slightly wider than the head and the same width as the base of the wing covers.

Figure 1. Adult emerald ash borer.

Larvae reach a length of 26 to 32 mm, are white to cream-colored, and dorso-ventrally flattened (Fig. 3). The brown head is mostly retracted into the prothorax, and only the mouthparts are visible. The abdomen has 10 segments, and the last segment has a pair of brown, pincer-like appendages.

Figure 2. Purplish red abdomen on adult beetle.

Biology

A. planipennis generally has a 1-year life cycle. In the upper Midwest, adult beetles begin emerging in May or early June. Beetle activity peaks between mid June and early July, and continues into August. Beetles probably live for about 3 weeks, although some have survived for more than 6 weeks in the laboratory. Beetles generally are most active during the day, particularly when it is warm and sunny. Most beetles appear to remain in protected locations in bark crevices or on foliage during rain or high winds.

Throughout their lives beetles feed on ash foliage, usually leaving small, irregularly shaped patches along the leaf margins. At least a few days of feeding are needed before beetles mate, and an additional 1 to 2 weeks of feeding may be needed before females begin laying eggs. Females can mate multiple times. Each female probably lays 30-60 eggs during an average lifespan, but a long-lived female may lay more than 200 eggs. Eggs are deposited individually in bark crevices or under bark flaps on the trunk or branches, and soon darken to a reddish brown. Eggs hatch in 7 to 10 days.

Figure 3. Second, third, and fourth stage larvae.

After hatching, first instar larvae chew through the bark and into the phloem and cambial region. Larvae feed on phloem for several weeks, creating serpentine (S-shaped) galleries packed with fine sawdust-like frass. As a larva grows, its gallery becomes progressively wider (Fig. 4). Beetle galleries often etch the outer sapwood. The length of the gallery generally ranges from 10 to 50 cm. Feeding is usually completed in autumn.

Figure 4. Gallery of an emerald ash borer larva.

Prepupal larvae overwinter in shallow chambers, roughly 1 cm deep, excavated in the outer sapwood or in the bark on thick-barked trees. Pupation begins in

Figure 5. D-shaped hole where an adult beetle emerged.

Figure 6. Jagged holes left by woodpeckers feeding on larvae.

Figure 7. Ash tree killed by emerald ash borer. Note the serpentine galleries.

Figure 8. Epicormic branching on a heavily infested ash tree.

late April or May. Newly eclosed adults often remain in the pupal chamber or bark for 1 to 2 weeks before emerging head-first through a D-shaped exit hole that is 3 to 4 mm in diameter (Fig. 5).

Studies in Michigan indicate 2 years may be required for *A. planipennis* to develop in newly infested ash trees that are relatively healthy. In these trees, many *A. planipennis* overwinter as early instars, feed a second summer, overwinter as prepupae, and emerge the following summer. In trees stressed by physical injury, high *A. planipennis* densities, or other problems, all or nearly all larvae develop in a single year. Whether a 2-year life cycle will occur in warmer southern states is not yet known.

Distribution and Hosts

A. planipennis is native to Asia and is found in China and Korea. It is also reported in Japan, Mongolia, the Russian Far East, and Taiwan. In China, high populations of *A. planipennis* occur primarily in *Fraxinus chinensis* and *F. rhynchophylla*, usually when those trees are stressed by drought or injury. Other Asian hosts (*F. mandshurica* var. *japonica*, *Ulmus davidiana* var. *japonica*, *Juglans mandshurica* var. *sieboldiana*, and *Pterocarya rhoifolia*) may be colonized by this or a related species.

In North America *A. planipennis* has attacked only ash trees. Host preference of *A. planipennis* or resistance among North American ash species may vary. Green ash (*F. pennsylvanica*) and black ash (*F. nigra*), for example, appear to be highly preferred, while white ash (*F. americana*) and blue ash (*F. quadrangulata*) are less preferred. At this time all species and varieties of native ash in North America appear to be at risk from this pest.

Signs and Symptoms

It is difficult to detect *A. planipennis* in newly infested trees because they exhibit few, if any, external symptoms. Jagged holes excavated by woodpeckers feeding on late instar or prepupal larvae may be the first sign that a tree is infested (Fig. 6). D-shaped exit holes left by emerging adult beetles may be seen on branches or the trunk, especially on trees with smooth bark (Fig 5). Bark may split vertically over larval feeding galleries. When the bark is removed from infested trees, the distinct, frass-filled larval galleries that etch the outer sapwood and phloem are readily visible (Fig. 4 and Fig. 7). An elliptical area of discolored sapwood, usually a result of secondary infection by fungal pathogens, sometimes surrounds galleries.

As *A. planipennis* densities build, foliage wilts, branches die, and the tree canopy becomes increasingly thin. Many trees appear to lose about 30 to 50 percent of the canopy after only a few years of infestation. Trees may die after 3 to 4 years of heavy infestation (Fig. 7). Epicormic shoots may arise on the trunk or branches of the tree (Fig. 8), often at the margin of live and dead tissue. Dense root sprouting sometimes occurs after trees die.

A. planipennis larvae have developed in branches and trunks ranging from 2.5 cm (1 inch) to 140 cm (55 inches) in diameter. Although stressed trees are initially more attractive to *A. planipennis* than healthy trees are, in many areas all or nearly all ash trees greater than 3 cm in diameter have been attacked.

Resources

For more information on the emerald ash borer and related topics...

- Visit the following Web sites:
  - Multi-agency Emerald Ash Borer Web Site: www.emeraldashborer.info
  - USDA Forest Service: www.na.fs.fed.us/fhp/eab/
  - USDA Animal and Plant Health Inspection Service: www.aphis.usda.gov/plant_health/
- Contact your state Department of Agriculture, State Forester, or Cooperative Extension Office.

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APPENDIX C. EMERALD ASH BORER MANAGEMENT AND TREATMENT OPTIONS

Eradication

The latest federal guidelines (USDA–APHIS 2013) state that in regards to EAB management, APHIS "has transitioned from an eradication program to an integrated pest management (IPM) program. Effective and cost efficient control and eradication technologies are not currently available." The 2013 federal guidelines state that APHIS will only consider management actions aimed at eradication if the site meets the following three criteria:

1. The outlier must be a single, clearly identifiable regulatory incident.
2. The population must be demonstrated to be less than two years old or to have no more than one population release from the original host material.
3. The population must be identified as eradicable by the EAB Management Team.

Containment

Established populations spread about one half mile per year (Vanderschaff and Jacobson 2011), but some gravid females are capable of flying over 12 miles per day (Taylor et al. 2006). Thus, it would be nearly impossible to stop the natural spread of an established EAB population. Conversely, aggressive containment and eradication of a newly detected satellite population can be more cost effective than trying to reduce EAB populations within the core of an infested area (Kovacs et al. 2011). The majority of ash growing in Montana are isolated as "islands" of urban trees or confined to riparian corridors, therefore, containment of a recently detected occurrence of EAB might be an appropriate strategy in Montana. A quarantine would typically contain EAB by restricting the following materials:

- firewood of all non-coniferous (hardwood) species
- *Fraxinus* sp. nursery stock
- *Fraxinus* sp.green lumber
- any part of a *Fraxinus* sp. tree, "living, dead, cut, or fallen, including logs, stumps, roots, branches, and composted and uncomposted chips" (USDA–APHIS 2013).

Treatment of infested material

Infested material must be disposed of in accordance with the federal guidelines to ensure EAB is not spread to new sites. Disposal includes bark removal, chipping, mulching, or composting by the criteria outlined in the USDA Emerald Ash Borer Program Manual, *Agrilus planipennis* (Fairmaire), ver. 1.3 (USDA–APHIS 2013). Some treatments include:

- *Bark removal* - remove all bark and an additional half inch of wood.
- *Chipping* - wood must be chipped to pieces that are no larger than one inch in at least two dimensions in order to be safe for landscape use.
- *Mulching and composting*- chipped woods that does not meet the size specifications above may be mulched or composted.

Biocontrol agents

As appropriate, Montana DNRC will apply for APHIS PPQ 529 permits to import approved biocontrol agents as outlined in the "Emerald Ash Borer Biological Control Release and Recovery Guidelines" (USDA-APHIS/ARS/FS 2012, http://www.nrs.fs.fed.us/disturbance/invasive_species/eab/local-resources/downloads/EAB-Biocontrol-Field-Guidelines-2012.pdf). Currently, the three permitted biological control agents for release in the United States are parasitoid wasps: *Tetrastichus planipennisi*, *Oobius agrili*, *Spathius agrili*. Based on results from initial deployment trials, it is likely that only the first two of the three approved wasps would be able to survive in the cooler climates of Montana.

Pesticides

Insecticides are currently the best option for controlling EAB populations in order to retain live ash. Systemic pesticides are most commonly used for treatment of EAB. These are applied to the exterior of the lower trunk as a spray, the soil as a drench or as granules, or injected directly into the tree stem where they dissipate through the vascular system. Systemic pesticides are most effective when used as a preventative measure, although they can be used to treat EAB infested trees that still retain >50% of their canopy. In a ten year simulation comparing the cost of treating trees with the most effective insecticide, emamectin benzoate (brand name TreeAge®), the cumulative costs of removing and replacing trees were four times higher than the cumulative cost of treating up to 50% of the ash trees with the systemic insecticide (McCullough and Mercader 2012). Emerald ash borer feed in and damage the tree's vascular system, so if their damage is extensive, the tree will not be able to adequately transport the chemical.

For an overview of insecticide options for EAB see:
http://www.emeraldashborer.info/files/Multistate_EAB_Insecticide_Fact_Sheet.pdf
For frequently asked questions about potential side effects of systemic insecticides for EAB:
http://www.emeraldashborer.info/files/potential_side_effects_of_eab_insecticides_faq.pdf

The following tables present some of the insecticides effective against EAB currently registered in Montana. Registration changes over time with some options added or excluded so it is the homeowner and licensed applicator's responsibility to check current registration information. The Montana Department of Agriculture (MDA) keeps a searchable database at: http://services.agr.mt.gov/Pesticide_Applicators/. Furthermore, homeowners and licensed applicator are responsible for reading and following all labels! All of the approved pesticides listed in this document are toxic to aquatic organisms, so care should be taken not to apply the pesticide to surface water, or an area with a shallow water table. Check the label for any required setback from open water and riparian areas. All of the approved pesticides listed in this document are also toxic to bees. Ash trees are wind pollinated so bees are not involved in pollination. However, bees could contact the pesticide when foraging on flowering plants growing where the insecticide was injected into the soil.

Homeowner options:

Homeowners may treat their trees using a soil drench or granular application of any of the systemic pesticides listed in the table below. By law, homeowners are permitted to make only one application per year, and labels restrict the amount of chemical that can be applied to trees of various sizes, and also impose per acre use limits.

The amount of insecticide required depends on the tree's circumference in inches; see product labels for specifications. The labeled rates are not as effective on larger trees, so homeowners should consider having trees that are greater than 15 inches diameter at breast height (dbh)(1.3 meters from base of tree) professionally treated. Do not make soil applications when soil is saturated or frozen. Before applying a soil drench, pull back any mulch or dead leaves 12 inches from the base of the tree. Replace any mulch over the treated area after the mixture has been absorbed into the soil. Grass and other plants around the base of the tree will also take up the pesticide, so for maximum effectiveness, remove the surrounding plants. Granules should be dispersed evenly on the soil around the base of the tree within 18" of the trunk. Irrigate after application with enough water to dissolve granules and move product into root zone. Ensure that children and pets do not have access to granules.
It is imperative that homeowners read and comply with pesticide labels.
For an explanation of how to calculate the number and sizes of trees in order to comply with per acre use limits of chemicals, see:
http://www.emeraldashborer.info/documents/EAB-Insecticdes-Label-Guidance-for-Use-Limits.pdf

Table 1. Products for Homeowner application

Type of Application	*Active Ingredient*	*Time of Application*
Soil Drench	Imidacloprid (1.47%)[1]	Spring **OR** late Aug through Sept
Soil Drench	Imidacloprid (2.94%)[2]	Spring **OR** late Aug through Sept
Soil Drench	Imidacloprid (0.74%) + Clothianidin (0.37%)[3]	Spring **OR** late Aug through Sept
Granular	Dinotefuran (2%)[4]	Spring to early June
Granular	Imidacloprid (2.5%)[5]	Spring to early June

*This table was adapted from Table 2 of Iowa State University's publication "Emerald Ash Borer Management Options" PM 2084.
[1]Examples of products include: Bayer Advanced 12 month Tree & Shrub Insect Control Concentrate, Bonide Annual Tree & Shrub Insect Control with Systemaxx, Compare N Save Systemic Tree & Shrub Insect Drench, Gordon's Tree & Shrub Insect Killer, Green Light Tree & Shrub Systemic Insect Killer, Ortho Bug B Gon Year-Long Shrub Insect Control Concentrate, Ortho Max Tree and Shrub Insect Control
[2]Bayer Advanced 12 Month Tree & Shrub Insect Control Concentrate
[3]An example of product is Bayer Advanced 12 month Tree & Shrub Protect & Feed Concentrate II
[4] Examples of products include: Green Light Tree & Shrub Insect Control with Safari 2G, Green Light Emerald Ash Borer Killer
[5] An example of product is Ortho Tree & Shrub Insect Control Granules

Professional Applicator Options:
Professional applicators can use soil drenches or injections. Emamectin benzoate is the only pesticides that provides two year of protection; it may even be effective for three years (Smitley et al. 2010). All of the systemic insecticides must be applied once every year, and the foliage and bark spray must be applied twice per season.

Table 2. Insecticides approved for professional use for treatment of emerald ash borer.*

Manufacturer	*Brand name*	*EPA registration number***	*Active ingredient*	*Formulation*	*Application method*	*Rate (a.i./inch dbh)*	*Timing*	*Tree size*
ArborJet	Tree-äge®	100-1309-74578	emamectin benzoate	4.0%	Trunk injection	0.1 – 0.8 g	Spring to fall; full canopy	Any healthy
ArborJet	IMA-*jet*®	74578-1	imidacloprid	5%	Trunk injection	4.0 – 8. 0 ml	Spring; full canopy	Any healthy
J.J. Mauget	Imicide®	7946-416	imidacloprid	10%	Trunk injection	1.0 – 2.0 ml	Spring; full canopy	Any healthy
NuFarm Americas	Mallett 2F T&O®	228-965	imidacloprid	21.40%	Soil injection or drench	3 - 6 ml	Spring; full canopy	Any healthy
NuFarm Americas	Mallett 2F®	228-485	imidacloprid	21.40%	Soil injection or drench	3 – 9 ml to 15″ DBH 9 – 12 ml >15″ DBH	Spring; full canopy	Any healthy
Bayer Environmental Science	Merit 75 WP®	432-1314	imidacloprid	75% WP	Soil injection or drench	1.4 g and 2.8 g	Low-rate spring only; high-rate spring or fall	Any healthy
Bayer Environmental Science	Merit 75 WSP®	432-1318	imidacloprid	75% WSP	Soil injection or drench	1.4 g and 2.8 g	Low-rate spring only; high-rate spring or fall	Any healthy
Bayer Environmental Science	Merit 2F®	432-1312	imidacloprid	2% F	Soil injection or drench	1.4 g and 2.8 g	Low-rate spring only; high-rate spring or fall	Any healthy
Manufacturer	*Brand name*	*EPA registration number***	*Active ingredient*	*Formulation*	*Application method*	*Rate (a.i./inch dbh)*	*Timing*	*Tree size*

Rainbow TreeCare Scientific Advancements	Xytect 75 WSP®	74779-13	imidacloprid	75% WSP	Soil injection or drench	0.03 – 0.06 oz	Low-rate spring only; high-rate spring or fall	Any healthy
Advan LLC	Enforce 75 WSP®	42750-117-83070	imidacloprid	75% WSP	Soil injection or drench	0.03 – 0.13 oz	Low-rate spring only; high-rate spring or fall	Any healthy
Rainbow TreeCare Scientific Advancements	Xytect 2F®	42750-115-74779	imidacloprid	2% F	Soil injection or drench	1.4 g and 2.8 g	Low-rate spring only; high-rate spring or fall	Any healthy
Bayer Environmental Science	CoreTect Tree & Shrub Tablets®	432-1457	imidacloprid	20% tablet	Soil insertion	2-3 tablets	Spring	Any healthy
Valent USA	Safari 20 SG®	33657-16-59639	dinotefuran	20% SG	Soil injection	3 – 12 g	Spring	Up to 12" DBH
Valent USA	Safari 2 SG®	59639-149	dinotefuran	2% SG	Soil application	2 – 4 oz	Spring	Up to 12" DBH
Rainbow TreeCare Scientific Advancements	Transtect 70 WSP®	59639-170-74779	dinotefuran	70% WSP	Basal-bark spray; soil injection, drench	***	Spring	Up to 12" DBH
FMC Agricultural Products Group	Onyx®	279-3177	bifenthrin	23.40%	Preventative bark and foliage spray	Three applications	Four-week intervals	Any healthy

* Adapted from Table 3 of "Emerald ash borer management options"; PM2084; Shour et al. 2013 (revised); Iowa State University Extension.
** Registered products are subject to change; it is the applicator's responsibility to ensure the product is labeled for use against emerald ash borer in the State of Montana.

APPENDIX D. INVENTORY OF PUBLICLY OWNED TREES IN MONTANA COMMUNITIES

*Inventoried Community**	*Year Inventoried*	*Percent of Ash trees*	*Number of Ash trees*	*Number of trees in inventory*
Alberton	2012	10.90	11	101
Anaconda	2011	27.90	351	1,258
Big Timber	2011	25.00	370	1,480
Billings[†]	2010	22.70	1,892	8,336
Bozeman[‡,~]	2010-2013	47.70	4,750	9,958
Broadus	2009	23.30	172	738
Butte[‡,~]	2012	15.24	674	4,423
Choteau	2012	40.00	542	1,355
Colstrip	2010	14.10	121	858
Cut Bank	2012	49.00	283	578
Dillon	2011	63.30	496	784
Drummond	2013	11.59	32	276
Eureka	2012	6.90	25	362
Forsyth	2008	28.40	203	715
Fort Benton	2012	64.20	573	893
Glendive	2013	30.45	609	2,000
Hamilton	2011	11.60	185	1,595
Havre	2012	70.30	2,497	3,552
Helena[‡,~]	2010	50.44	5,598	11,099
Kalispell[~]	2008-2009	5.99	415	6,930
Laurel	2011	68.00	2,292	3,371
Lewistown	2012	37.00	1,492	4,032
Libby	2013	4.10	49	1,195
Livingston	2009	47.14	1,936	4,107
Malmstrom AFB	2010	14.37	809	5,631
Manhattan	2013	17.50	168	960
Missoula[‡,~]	2012-2013	12.22	2,511	20,545
Polson	2010	7.50	120	1,600
Red Lodge	2008	9.41	201	2,137
Ronan	2013	5.70	30	526
Roundup[‡]	2010	23.30	10	43
Shelby	2013	40.89	558	1,365
Sheridan	2013	20.60	29	141
Sidney	2013	29.74	632	2,125

*Inventoried Community**	*Year Inventoried*	*Percent of Ash trees*	*Number of Ash trees*	*Number of trees in inventory*
Stanford	2012	66.70	198	297
Stevensville	2013	9.84	62	630
Superior	2013	4.00	14	350
Valier	2012	32.80	185	564
White Sulphur Springs	2012	2.40	12	500
Whitefish	2013	11.30	437	3,868
Whitehall	2012	47.20	186	394
Cascade	2014	33.18	146	440
Columbus	2014	66.85	821	1,228
Conrad	2014	65.03	798	1,227
Culbertson	2014	14.12	50	354
Ennis	2014	32.40	70	216
Fort Peck	2014	16.88	102	604
Plentywood	2014	27.30	172	630
Thompson Falls	2014	2.52	11	436
West Yellowstone	2014	0.00	0	655
Wolf Point	2014	16.64	221	1,328
Saco	2014	35.83	43	120
Lodge Grass	2014	34.00	34	100
Judith Gap	2014	17.30	46	270
Hardin	2014	45.30	521	1,150
Columbia Falls	2009	1.92	65	3,378
SUMMARY	2008-2014	**28.13**	**34,830**	**123,806**

*only publically owned trees were inventoried, this includes trees in a public right of way or park

†only parks trees were inventoried

‡only mainstreet and parks were inventoried

¨estimated #, inventory not yet complete

APPENDIX E. GREEN ASH PROFILE FOR MONTANA

Source: Trees and Shrubs in Montana, Montana State Extension, http://msuextension.org/publications/OutdoorsEnvironmentandWildlife/2B0323.pdf

Green Ash

(Fraxinus pennsylvanica)

The green ash is a meduim-sized, usually round-topped tree 30-50 feet tall with slender, spreading branches. Although usually found along the banks of streams, it also is relatively drought tolerant and is often planted for windbreaks and beautification purposes.

Leaves: With seven to nine leaflets, usually seven. Leaflets 2-4 inches long, and 1 1/2 inches wide. Long, pointed tips, finely toothed margins. Bright green on both surfaces.

Fruit: Single-seeded, with a long, narrow wing, 1-2 1/2 inches long.

Bark: Gray to brown, tinged with red, slightly furrowed, 1/2-2/3 inch thick.

47